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Mortality and growth of tree species under stress at Lake Toolibin in the Western Australian Wheatbelt

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Abstract

Tree species occupying the bed and margins of Lake Toolibin, an ephemeral lake of the Northern Arthur River system in the central Western Australian Wheatbelt, were permanently marked in 1983 and then remeasured after 5 years to determined survival, growth and vigour. Trees of the lake margins, *Eucalyptus rudis* and *Melaleuca strobophylla*, showed the greatest mortality, greatest reduction in vigour classification and smallest growth increments to the environmental conditions of the lake now being affected by secondary salinisation. The upland species, *Acacia acuminata* and *Allocasuarina huegeliana*, also showed elevated levels of mortality and reduced vigour, but had the highest annual growth increments of the species measured. *Casuarina obesa* populations in the more saline areas of the lake environment showed increased mortalities, decreased vigour and reduced growth compared to the trees of areas of the lake environment with more favourable conditions.

Introduction

Lake Toolibin (32°56'S, 117°11'E) is one of the few comparatively fresh water lakes in the central Western Australian Wheatbelt and one of particular importance as a waterfowl breeding location. The lake lies at the head of the chain of shallow ephemeral lakes of the Northern Arthur River, a tributary of the Blackwood River System, in the Wickepin Shire. All other lakes of the Arthur River System have been severely affected by secondary salinization and the Shire has lost more than 3% of its formerly arable land to the effects of increased salinity and flooding (NARWRC 1978).

Lake Toolibin and its surrounds, incorporated in Reserves 27286 and 9617, have been intensively monitored since the impacts of secondary salinization were first noticed in the early 1970s (NARWRC 1978). Currently the Department of Conservation and Land Management is engaged in a tree planting and groundwater pumping operation to restrict the further decline of this important region of indigenous flora and fauna.

Detailed mapping of topographical, environmental and vegetational features revealed patterns of plant community distribution and relative health and vigour of the communities in relation to the input of salinity from the several drainage systems (Froend *et al* 1987). *Casuarina obesa* dominates the seasonally inundated lake bed. *Melaleuca strobophylla* occurs on slightly raised sections of the lake floor and *Eucalyptus rudis* can be found along the margins of the lake and inlet drains. Upland areas around the lake are dominated by open woodlands of *Eucalyptus loxophleba*, *Allocasuarina huegeliana* and *Acacia acuminata*.

Study of the patterns of tree deaths in the lake environment has indicated that the increasing salinity levels have adversely affected the populations of *Casuarina obesa* and *Melaleuca strobophylla* while both increased salinity and prolonged inundation have affected *Eucalyptus rudis* (Froend *et al* 1987). The current study reports on the mortality, change in tree vigour and incremental growth achieved in permanently marked populations from 1983 to 1988.

Methods

Five study areas were established during the Autumn of 1983 in and around Lake Toolibin. All trees were tagged at breast height with a permanent aluminium tag, mapped, measured for diameter and subjectively scored for vigour (0 = healthy to 9 = dead). The elevation of each tree in relation to lake levels was determined in Autumn, 1983.

Although it is realized that soil salinity levels vary greatly with season, the 1983 data on the percentage of the dry soil weight as NaCl contribute some indication of the severity of each study area (Table 1).

Table 1

Features of the tagged tree plots (After Froend *et al* 1987).

Area 1 A transect of four plots (each c. 20m X 20m) grading from the western upland of the Northern Arthur River channel dominated by *Eucalyptus loxophleba* across the *Casuarina obesa* - dominated floodplain and up into the eastern upland woodland. All elevation are above mean lake level. Salinity levels in March 1983 ranged between 0.04 % NaCl in the uplands to 0.13 % in the heavy soils near the channel margin.

Area 2 A transect of 3 plots grading from upland *E. loxophleba* - *Acacia acuminata* woodland into the lake basin region dominated by *Casuarina obesa* on the eastern margin of the lake where water conditions tended to be fresher. Salt concentrations in the upland were low, at 0.04 % NaCl. Some lake bed sections in this area reached 0.12% NaCl in March 1983.

Area 3 A location of 4 plots on the western edge of the lake just south of the Western Drain, the source of a major input of salts and the major region of tree damage in 1983. Upper reaches are dominated by *Eucalyptus rudis* with *Casuarina obesa* and *Melaleuca strobophylla* in the lake bed portions of the area. Mean soil salinity levels reached 0.30 % NaCl.

Area 4 A relatively flat region in the central part of the lake basin harbouring a monoculture stand of *Casuarina obesa* some 300 m east of Site 3. The two plots had a mean soil salinity of about 0.07% NaCl. Inundation percentages were the highest of the study sites due the central basin location.

Area 5 A single plot site located in the Northwest Creek drainage, an area of moderate input of salinity. This plot was not analysed for soil salinities in 1983. The major species of the lowlying area was *Casuarina obesa* with *E. rudis* in marginally higher sections of the area.

In May 1988, all trees were remeasured for diameter at breast height with diameter tapes and again scored for vigour class. The permanent tag at breast height ensured that the measurements were taken at the same circumference of the tree as previously. The percentage mortality of trees and change in diameter and vigour for all species, except *Casuarina obesa*, were determined by combining the data for all sites. Sufficient numbers of *Casuarina obesa* allowed comparisons of the several locations within the lake environment on the mortality, vigour and growth.

Results

The two common lake bed/lake margin species, *Melaleuca strobophylla* and *Eucalyptus rudis*, showed relatively high mortality rates with nearly a quarter of the tagged trees dying in the 1983-1988 period (Table 2). Mortality was also relatively high in the upland species *Acacia acuminata* and *Allocasuarina huegeliana*, however, mortality was nil in *Eucalyptus loxophleba*. Change in vigour class mirrored the mortality percentages with *Melaleuca strobophylla* showing the greatest mean change in vigour and *Eucalyptus loxophleba* showing the least change in vigour over the five year period. The separate population calculations of mortality, vigour and growth in *Casuarina obesa* revealed that mortality was highest at the midlake region (area 4), but in general most trees tagged in 1983 survived until the resample period of 1988 (Table 3). Trees of the lake bottom near the eastern perimeter at area 2 showed the greatest change in vigour, a reduction of more than 4 units in the 5 years. Total growth increment was smallest in the trees of the midlake site (area 4) and the lake bottom trees growing on the western edge of the lake (area 2), but the growth rates of *Casuarina obesa* at some of the other sites were comparable to those tree species growing in the apparently more favourable habitats above the lake margin.

Table 2

Percentage mortality, change in vigour class and increment growth of tree species of Lake Toolibin, Western Australia

Values are means ± standard deviations. The annual increment was determined as one-fifth of the 5 year change in diameter

Species	N	Mortality %	Change in Vigour	Growth Increment (cm) 1983-1988	Annual
Acacia acuminata	14	21	-2.0 ± 1.8	2.34 ± 2.09	0.47
Allocasuarina huegeliana	8	25	-1.7 ± 1.4	1.90 ± 2.16	0.38
Eucalyptus loxophleba	14	0	-0.7 ± 0.7	1.02 ± 0.75	0.20
E. rudis	16	25	-1.7 ± 2.7	0.32 ± 1.00	0.06
Melaleuca strobophylla	15	27	-4.4 ± 2.7	0.47 ± 1.07	0.09

Table 3

Percentage mortality, change in vigour class and increment growth (± sd) of *Casuarina obesa* populations growing on the bed of Lake Toolibin, Western Australia

Area	N	Mortality %	Change in Vigour	Growth Increment (cm) 1983-1988	Annual
1	39	10	-2.0 ± 1.7	1.26 ± 1.14	0.25
2	22	0	-3.7 ± 4.0	0.80 ± 0.91	0.16
3	23	4	-0.2 ± 1.7	1.34 ± 1.06	0.27
4	87	17	-1.6 ± 1.3	0.44 ± 0.44	0.09
5	17	0	-0.8 ± 0.8	1.44 ± 0.62	0.29

Discussion

Species commonly occupying regions of annual flooding have a high tolerance of saturated soil conditions (Pereira & Kozlowski 1977) and often can tolerate considerable increase in flooding duration before death occurs (Green 1947). Several years of permanent inundation are required to cause death in such species (Yeager 1949, Eggler & Moore 1961).

The tolerance of river bottom or ephemeral lake species to the combined stresses of increased flooding durations and increased salinity, however, has not been previously recorded. Australia is somewhat unique in that the clearing of large tracts of woodland is now resulting in the combined stresses of increased waterlogging durations and higher levels of soil salinity occurring in catchment discharge areas (Nulsen 1986). The response of the vegetation in the Lake Toolibin region to secondary salinization seems to have been one of greater effect on the lake margin species than those inhabiting the environments of the lake bottom or the upland regions unaffected by inundation. *Casuarina obesa* has been shown to be highly tolerant of salinity and waterlogging stresses (van der Moezel *et al* 1988). Although areas of high *C. obesa* mortality exist, over the majority of the lake bed the increase in stress apparently still lies within the limits of tolerance for the mature *C. obesa* trees. In *Melaleuca strobophylla* and *Eucalyptus rudis*, however, the longer periods of saturated soil profiles induced by the clearing of upland recharge zones of the catchments and the increased levels of groundwater salinity have combined to stress individuals of these two species to the point of mortality. *Eucalyptus rudis* has been previously shown to be adversely affected by increasing periods of soil saturation (Froend *et al* 1987). Certain species of *Melaleuca*, for example, *M. acacioides* (Barlow 1986) and *M. styphelioides* (Midgley *et al* 1986), show tolerance to soil salinity, but no studies on *M. strobophylla* have been carried out to indicate suspected abilities to tolerate increasing levels of flooding conditions or groundwater salinity. The present study indicates that these species appear sensitive to secondary salinization and require careful monitoring in the future for further degradation of stream courses in the central Wheatbelt.

The mortality of the upland species is more difficult to explain. Remnant woodlots in rural areas of Australia have reputedly suffered large tree population losses since the late 1960s and early 1970s. This decline in rural tree populations is probably due to several reasons. The first, loss due to removal of trees as part of farm management, and the second, due to old age, coupled with a paucity of recruitment of tree seedlings because of active suppression, grazing and competition with improved pastures, are easily understood reasons for rural tree population decline. In the present study deaths in *Acacia acuminata*, *Allocasuarina huegeliana* and *Eucalyptus rudis* occurred in reasonably large trees but it would be difficult to conclude that all deaths were due to old age. A third element, "rural dieback", the premature and relatively rapid decline and death of native trees on farms, is apparently a consequence of interacting environmental stresses and remains largely unexplained (Old *et al* 1981). It is apparent, however, that remnant woodlands in rural landscapes represent ecosystems which are precariously balanced (Wylie & Landsberg 1987). Rural woodlands have little chance of survival unless supplemented by replanting or by natural regeneration. The data of the present study further document this phenomenon, but provide no clues to its cause.

The efforts of the Department of Conservation and Land Management to reafforest the upland margins of the Lake Toolibin reserves and the pumping of saline groundwaters from the lake basin environment should provide a more favourable habitat for the present population of trees and encourage natural recruitment. The Lake Toolibin reserves would be a logical location to establish a more extensive series of plots to study seedling recruitment and mortality and crown condition by age class of each major species of the area. Hopefully the patterns of poor survival, decline in vigour and slow growth rates recorded during the past five year period will be reversed in the future.

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